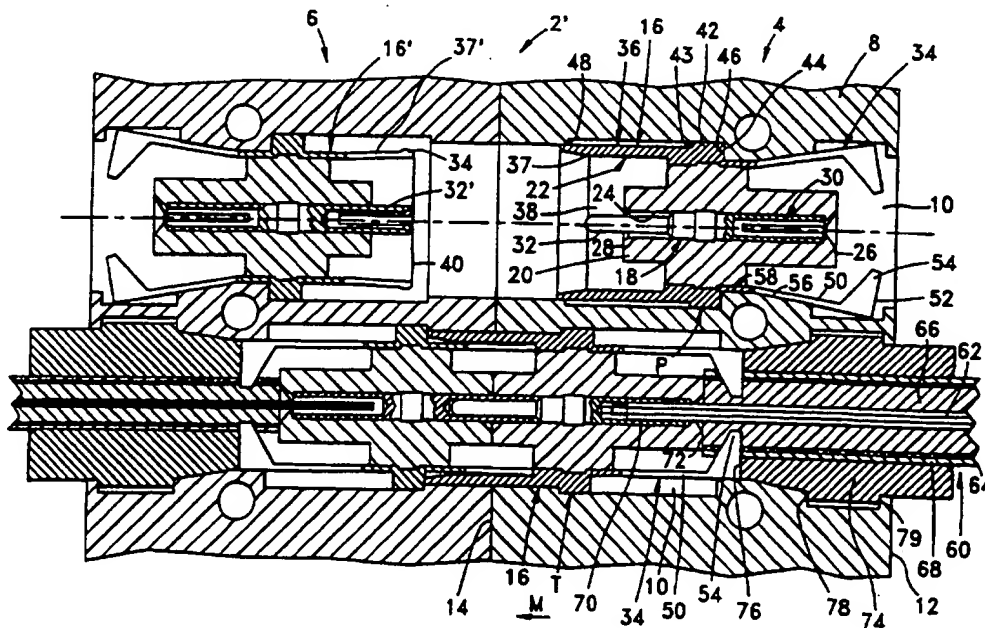




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<p>(21) International Application Number: PCT/IB97/00189</p> <p>(22) International Filing Date: 3 March 1997 (03.03.97)</p> <p>(30) Priority Data: 9605225.3 12 March 1996 (12.03.96) GB</p> <p>(71) Applicant (for all designated States except US): THE WHITAKER CORPORATION [US/US]; Suite 450, 4550 New Linden Hill Road, Wilmington, DE 19808 (US).</p> <p>(72) Inventors; and (75) Inventors/Applicants (for US only): DUQUERROY, Patrick [FR/DE]; Friedhofstrasse 22, D-63500 Seligenstadt (DE). MEIER, Pierre-André [CH/CH]; Les Plumasses, CH-1867 Antagnès s/Ollon (CH).</p> <p>(74) Agents: NINA, Driscoll, A. et al.; AMP International Enterprises Ltd., AMPèrestrasse 3, CH-9323 Steinach (CH).</p>		<p>(81) Designated States: CN, JP, KR, SG, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).</p> <p><b>Published</b> <i>With international search report.</i></p>

(54) Title: COAXIAL CONNECTOR WITH INSULATION PIERCING CONTACTS



## (57) Abstract

A coaxial connector assembly (2) comprises a housing (8) having cavities (10) extending therethrough and receiving coaxial connectors (16). Each coaxial connector (16) has an outer conductor (22) having insulation piercing arms (50) for piercing through the insulation layer (68) of a coaxial cable, thereby contacting the outer conductor (64) of the cable. Simple and rapid assembly of the cable to the coaxial connector is thus provided.

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COAXIAL CONNECTOR WITH INSULATION PIERCING CONTACTS

This invention relates to a coaxial connector having insulation displacing contacts for easy connection to  
5 coaxial cables. The invention further relates to a versatile multi-position modular coaxial connector system.

A coaxial cable typically comprises an inner conductor concentrically surrounded by a dielectric which is in its turn concentrically surrounded by an outer  
10 conductor, for example a braided wire conductor, which is surrounded by an outer insulating layer. In order to terminate a coaxial cable to a conventional coaxial connector, a section of the outer insulating layer must first be removed exposing a certain length of the outer  
15 conductor, and a portion of this exposed region of outer conductor and dielectric must then be removed to expose a certain length of inner conductor. The inner and outer conductors are then clamped to corresponding inner and outer conductors of a coaxial connector for connection  
20 thereto. Exposing certain lengths of both inner and outer conductors, in specified proportions, requires special tooling and is relatively time consuming. Removal of the outer insulation layer to expose the outer conductor, may also damage the outer conductor which is usually quite  
25 thin. The assembly of conventional coaxial connectors to coaxial cables is not well adapted for multi-position coaxial connectors where a plurality of inner and outer conducting pairs are positioned in a single housing. The outer and inner conductor pairs first need to be attached  
30 or assembled to their respective coaxial cables and then mounted into the housing, as access to the outer conductor during assembly is typically needed. This renders multi-position coaxial connectors either more complex, bulkier, or costly to assemble.

35 In certain applications, multi-position coaxial connection systems are desired in order to distribute coaxial signals, for example from a T.V. satellite dish to a number of users. In such applications, it would be

advantageous to have a versatile multi-position coaxial connection system that enables connectors with different numbers of coaxial connectors to be interconnected in versatile combinations. It would be advantageous to provide a versatile connection and distribution system for distributing and interconnecting coaxial cables, in particular, one that allows easy expansion of the number of connectors for distributing common signals.

It is an object of this invention to provide a coaxial connector that enables easy and rapid assembly and electrical connection of a coaxial cable thereto.

It would be advantageous to provide a cost effective and compact multi-position coaxial connector assembly.

It would be advantageous to provide a coaxial connector that does not require exposing the outer conductor for connection thereto.

It would be advantageous to provide a versatile coaxial connection distribution system for multi-position coaxial connections.

It would be advantageous to provide a modular interconnection system for multi-position coaxial connection assemblies.

Objects of this invention have been achieved by providing a coaxial connector assembly comprising a housing and a coaxial connector mounted therein, the coaxial connector comprising an inner conductor and an outer conductor separated therefrom by a dielectric, wherein the outer conductor comprises insulation displacing contacts having cutting blades for piercing through the outer insulation of a coaxial cable. Advantageously therefore, the outer conductor does not need to be exposed prior to connection to the connector thereby facilitating termination to the cable.

A plurality of insulation piercing blades can be disposed around the circumference of the cable to be connected. The latter enhances the reliability and quality of the electrical connection between the coaxial outer conductor and the cable outer conductor.

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Termination of the connector outer conductor to the cable may occur during assembly of the cable into the connector when the connector is positioned in the connector assembly housing. This enables, inter alia, cost effective assembly of the cable to the connector assembly.

The connector assembly housing can be provided with camming surfaces that engage the insulation displacing contacts of the connector outer conductor, such that during assembly of the cable to the assembly, the camming surfaces resiliently bias the insulation displacing contacts into electrical contact with the cable outer conductor.

Further advantageous features and details of the invention are described in the claims, or will be apparent from the description and drawings.

Other objects of this invention have been achieved by providing a coaxial distribution and interconnection assembly system comprising connection assembly modules pluggable together and securable by cooperating latching means, the latching means being hermaphroditic such that identical multi-position coaxial connection assemblies can be intermated, wherein the latching system is adapted to enable a single, or a plurality of adjacent connection assembly modules to be plugged to a multi-position coaxial connector assembly. In other words, a plurality of multi-position coaxial connection assemblies with different numbers of coaxial connections, can be plugged together to form the desired distribution and interconnection assembly with the required number of coaxial distribution points.

The latching system may comprise a groove extending along a corner of a mating face of a multi-position coaxial connection assembly, and a corresponding protrusion extending beyond the mating face on the opposing corner of the connection assembly, whereby the coaxial connectors serve to center and position the mating connectors. A very compact latching system is thus provided, which is independent of the lateral position of a mating connector thereby enabling connection modules of

different numbers of positions (i.e. connectors) to be interconnected.

Further advantageous aspects and details of the invention are described in the claims, or will be apparent from the description and drawings.

Embodiments of this invention will now be described by way of example by reference to the figures, whereby;

Figure 1 is a cross-sectional view through part of a connection assembly comprising first and second multi-position coaxial connector assemblies having coaxial connectors, where one of the coaxial connectors is terminated to a cable, and the other is unterminated;

Figure 2a is a cross-sectional view of the outer conductor of a coaxial connector in a preassembly position;

Figure 2b is a view in the direction of arrow 2b of the outer conductor of Figure 2a;

Figures 2c and 2d are similar to Figures 2a and 2b respectively, but with the outer conductor in a fully assembled (terminated) position electrically connected to an outer conductor of a coaxial cable;

Figure 3 is an exploded view of a number of coaxial connection assembly modules that are pluggable together to form a coaxial interconnection and distribution system;

Figure 4 is a cross-sectional view through first and second connection assemblies plugged together;

Figure 5 is a view similar to that of Figure 4, but with the connector assemblies unplugged, only just engaging each other.

Referring to Figures 1 and 2, a multi-position coaxial connection assembly 2, comprises a first connector assembly 4 and a second connector assembly 6 matable therewith. The first connector assembly 4 comprises a housing 8 comprising a plurality of cavities 10 extending therethrough from a cable receiving end 12 to a mating end 14. The first connector assembly 4 further comprises a plurality of coaxial connectors 16 mounted in the cavities 10. Each connector 16 comprises an inner terminal 18

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concentrically surrounded by a dielectric 20, which is concentrically surrounded by an outer terminal 22. The dielectric housing 20 holds the inner terminal 18 in position with respect to the outer terminal 22. The inner  
5 terminal 18 is mounted in a central cavity 24 of the dielectric 20 extending from a conductor receiving end 26 to a mating end 28. The inner terminal 18 comprises a connection section 30 and a contact section 32 that can  
10 either be a pin contact as shown for the first connector 4 or a receptacle contact 32' of the mating coaxial connector 16' that differs from the connector 16 substantially only in the mating contact area.

The outer conductor 16 comprises a connection section 34 and a contact section 36. The contact section 36  
15 comprises a shroud 37 forming a cavity 38 for receiving a flexible shroud portion 37' of the mating connector 16' therein. The flexible shroud portion 37' has protrusions 39 at a mating end 40 that engage the inner surface of the shroud 37 for electrical contact therewith.

20 Between the connection section 34 and the contact section 36, is a transition section 42 that has front and rear retention shoulders 43,44 respectively, abutable against corresponding shoulders 46,47 respectively in the housing cavity 10 for retaining the connector 16 therein.  
25 The shoulders 46,48 in the housing are separated by a distance that allows slidable movement of the connector 16 from a preassembly position P to a fully terminated and assembled position T, the sliding movement being in the mating direction M of the connectors 4,6. The  
30 complementary receptacle connector 16' and second connector 6 are provided with similar features.

The outer conductor connection section 34 comprises a plurality of insulation piercing contact arms 50  
35 extending rearwardly from the transition section 42 in an outwardly oblique manner when in the preassembly position P. There are a plurality of insulation piercing arms 50 positioned around the circumference of the connector. The arms 50 are in the form of cantilever beams attached

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proximate the transition section 42 and extending to free ends 52 proximate the cable receiving end 12 of the connector assembly. Insulation piercing blades or knives 54 project radially inward and are disposed at the free ends 52 of the arms 50. The blades 54 have sharp pointed tips 55 that are the result of machining slots 57 (see Figure 2d) of constant width (G) in the terminated position, the slots extending radially across the central axis 59 of the connector 16. The arms 50 are subsequently outwardly deformed to produce the outer conductor in its preassembly shape, as shown in Figure 2a.

At the position of the insulation piercing arms 50 when the connector 16 is in the preassembly position P, the housing cavity 10 is provided with a corresponding tapered wall portion 56 against which the insulation piercing arms 50 abut in their natural state. The tapered surface 56 narrows, toward the mating end 14, to a reduced diameter camming portion 58 that serves to inwardly bias the insulation piercing arms 50 when the connector 16 is moved from the preassembly position P to the fully assembled position T. This occurs when a coaxial cable 60 is assembled to the connection assembly 4.

The coaxial cable comprises an inner conductor 62, an outer conductor 64 and a dielectric 66 therebetween, the cable 60 further comprising an outer insulating layer 68 surrounding the outer conductor 64.

Assembly of the cable to the connector is effected as follows. First, an end portion 70 of the inner conductor 62 is exposed. The cable is then inserted into the cavity 10 whereby the inner conductor end portion 70 is inserted into the connection end 30 of the connector inner terminal 18. The inner terminal 16 connection section 30 may be provided with resilient claws that dig into the cable inner conductor for electrical connection therewith. Other conventional connection means can also be considered. Upon insertion of the inner conductor into the inner terminal connection section 30, the cable end 72 abuts the cable receiving end 26 of the connector

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dielectric 20. Further insertion of the cable into the cavity 10 pushes the connector in the mating direction, whereby the insulation piercing arms 50 are inwardly biased by the cavity camming surfaces 58. The latter thus results in the insulation piercing blades 54 piercing through the cable outer insulation 68 and electrically contacting the outer conductor 64. A plug 74 is then mounted in the cable receiving end of the cavity 10, the plug having a forward shoulder 76 in abutment with or close to the connection section 34 of the connector 16 in order to retain the connector in the fully assembled position T. The plug 74 is itself provided with retention shoulders 78,79 that engage with corresponding shoulders in the cavity 10 of the housing. The plug 74 could also be premounted to the cable 60, and assist in pushing the connector 16 from the preassembly to the fully assembled position. It could also be considered to provide the plug 74 not mounted to the cable 60 and used to stuff the connectors into the fully assembled position (rather than pushing on the cable). It would also be possible to provide a plurality of plugs 74 integrally attached together for terminating a plurality of connectors 16 of the connector assembly 4 in a single operation.

Referring to Figures 4 and 5, the connectors 4 and 6 are provided with latching members 79,81 and 79',81' respectively at opposed corners 80,82 and 80',82' of the first and second connectors 4,6 respectively. The corners 80,82,80',82' are at the connector assembly mating faces 14,14' respectively. The latch member 74 at the corner 80 comprises an extension in the mating direction M having an arcuate locking protrusion 86 and corresponding groove 88 therebehind. A corresponding recess 90' and protrusion 92' at the corner 82' of the second connector 6 engage contiguously the protrusion and groove 86,88 respectively of the first connector 4. On the opposing corners 82,82' of the connectors 4,6 respectively, the same latching members are provided, but swapped over as depicted in the figures. The latter thus provides for a hermaphroditic

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latching member. In other words, the same housing 8 and 8' can be provided for the connectors 4 and 6 for receiving the connectors 16 and 16' respectively. The location and centering of the mating connectors is provided by engagement of the outer and inner terminals of the mating connectors. The latching members merely serving to hold the coupled connectors together. The latching protrusion and grooves 86,88,90',92' extend along the whole length of the connector corners 80,82'. The latter enables, for example, a four position connector 4' to be connected to a four position connector interface 107' of a connection assembly distribution module 106', as depicted in Figure 3, or for example, two 2 position connectors positioned adjacent each other could be mated with the interface 107'.

The latching system is also particularly compact. In particular when considering the short length in the direction of coupling M.

Referring to Figure 3, a coaxial interconnection and distribution system 100 is shown comprising distribution modules 106,106' multi-position cable connector assemblies 4,4' and other multi-position cable connector assemblies 104. The distribution modules 106,106' each comprise a housing 108 having front and back walls 110,112 and opposed side walls 114,116. A plurality of pin coaxial connectors 16 extend through the front wall 110 to form a connector interface 107,107' and a corresponding plurality of receptacle coaxial connectors 16' extend through the opposing back wall 112. Coaxial connectors 16 also extend through the side walls 114,116 to form further connector interfaces 109,109'. The distribution module 106 can be plugged to another distribution module 106' identical to the module 106 in order to extend the module, for distribution to a plurality of cable connector assemblies 104 that plug into the interface 109,109'. A multi-position coaxial connector assembly 4 can be plugged to the end wall 112 interface, or a similar connector 4' but with complementary coaxial terminals can be plugged to the

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front wall interface 107'.

- 5 Modules 106,106',104,4,4' can thus be built up to interconnect and distribute apply the required number of coaxial lines, the connectors being latched together in a compact manner and enabling modules with different numbers of connector positions to be connected together if this is desirable.

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CLAIMS

1. A coaxial connector assembly (4,6) comprising a housing (8) having a cavity (10) extending therethrough from a cable receiving end (12) to a mating end (14), the assembly further comprising a coaxial connector (16) mounted in the cavity (10), for connection to a coaxial cable (60) having an inner conductor, outer conductor and a dielectric therebetween; the connector having an inner electrical terminal (18), an outer electrical terminal concentrically surrounding the inner terminal, and a dielectric housing therebetween, the outer conductor having contact section (22) for mating with a complementary contact, a connection section (34) for connection to the outer conductor (64) of the cable (60), and a transition section (42) therebetween, characterized in that the connection section (34) comprises an insulation piercing arm (50) having a blade (54) for piercing through the outer insulation layer of the coaxial cable to make electrical contact with the outer conductor thereof.
2. The assembly of Claim 1 wherein the coaxial connector connection section comprises a plurality of blades (54) disposed around the circumference of the connector (16).
3. The assembly of Claim 2 wherein there are more than two insulation piercing arms (50) disposed around the circumference of the connector (16).
4. The assembly of claim 3 wherein the plurality of insulation piercing arms are disposed in an axi-symmetric manner about the circumference.
5. The assembly of any preceding claim wherein each insulation piercing arm is in the shape of a cantilever beam, attached at one end to the transition section (42) and extending to a free end (52).

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6. The assembly of Claim 5 wherein the blade (54) is disposed at the free end (52).

7. The assembly of any preceding claim wherein the connector housing comprises a camming surface (58) engageable with the insulation piercing arm, for biasing the blade (54) into piercing engagement with the cable (60) when the connector assembly is assembled to the cable.

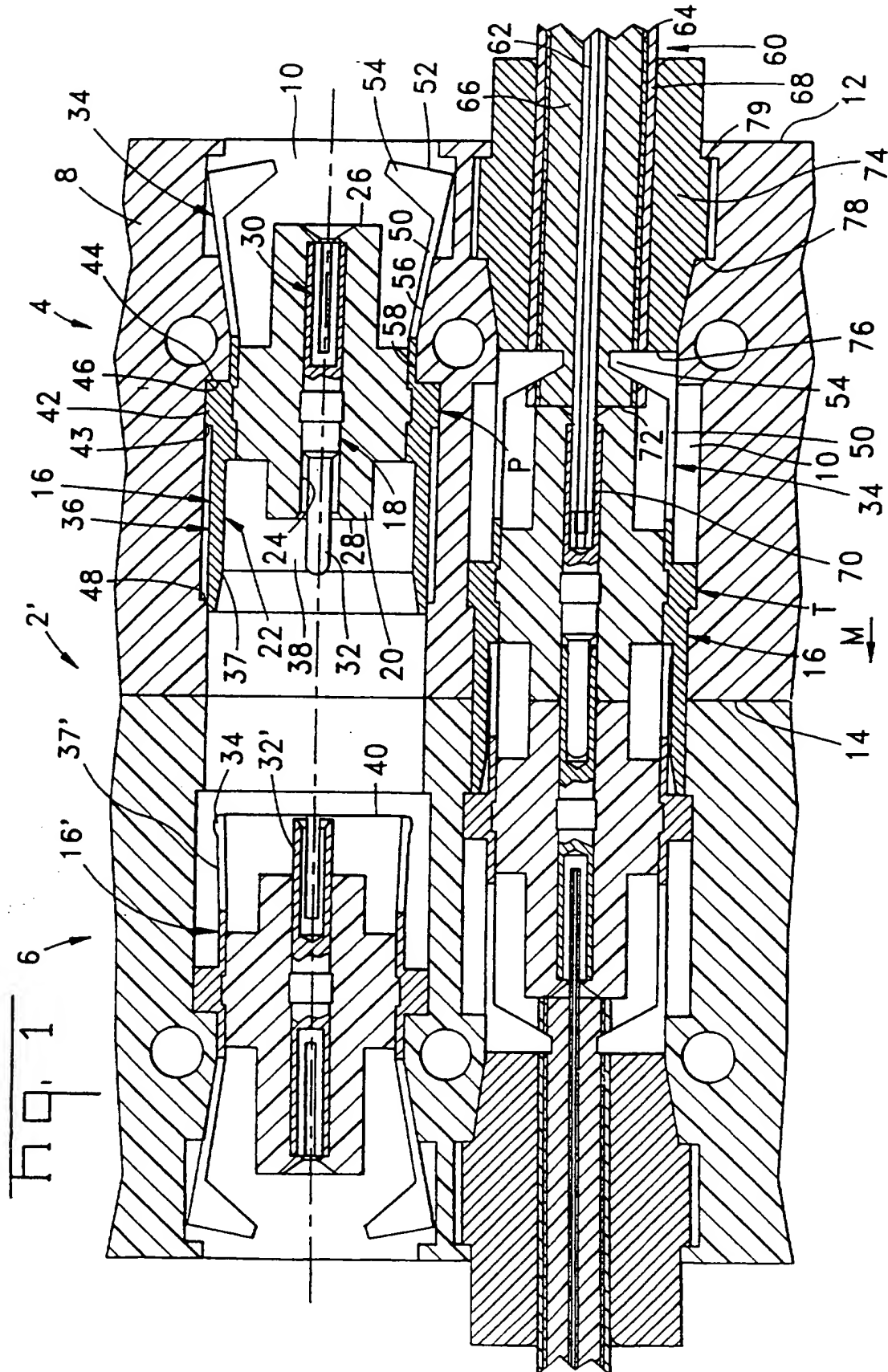
8. The assembly of Claim 7 wherein the connector (16) is slidably movable in the assembly coupling or mating direction (M), from a preassembly position (P) where the connector is not terminated to the cable (60), to a fully terminated position (T) where the connector is electrically connected to the cable.

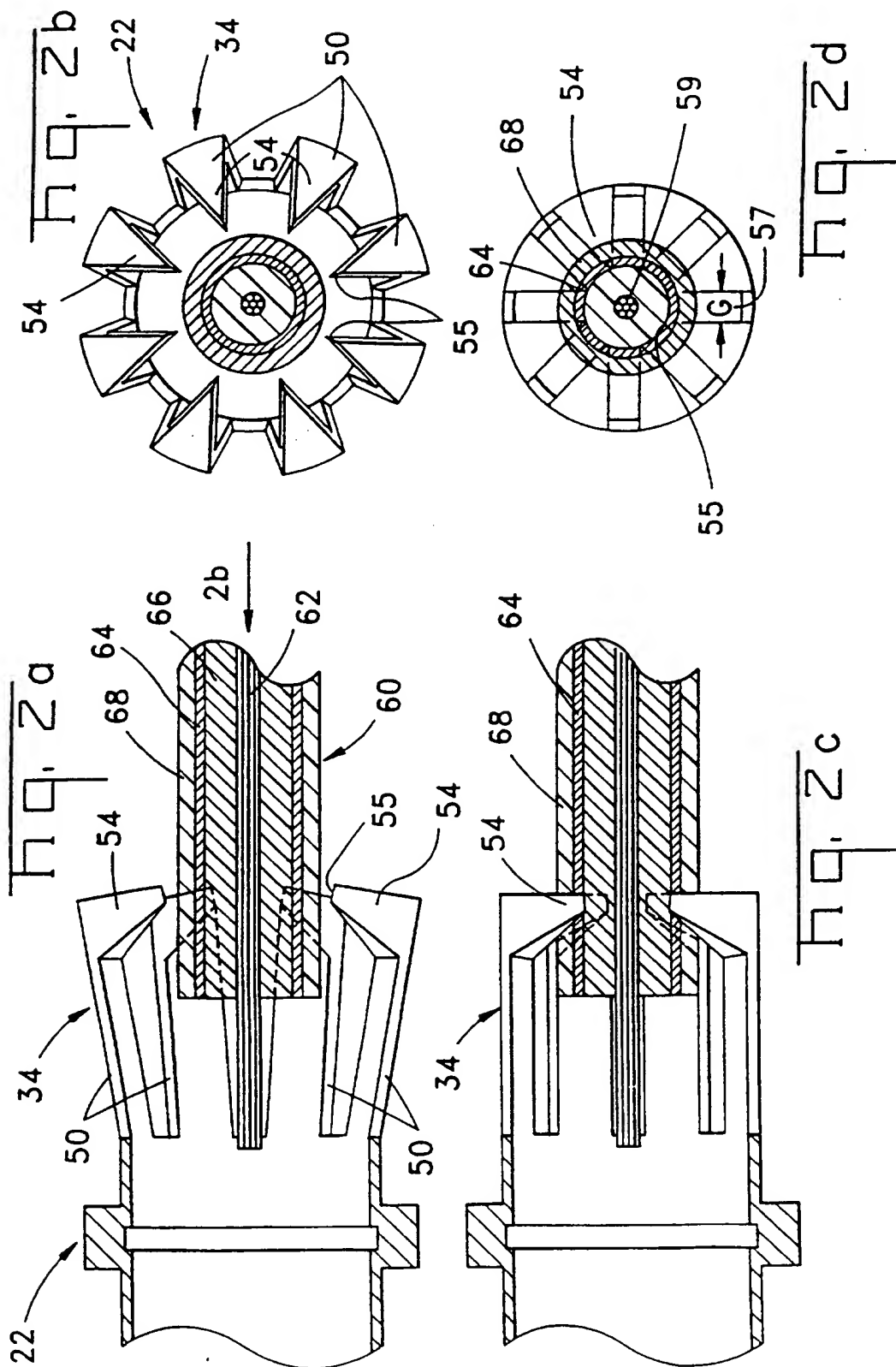
9. The assembly of Claim 8 wherein the camming surface (58) is provided as a restrictive diameter section of the cavity (10).

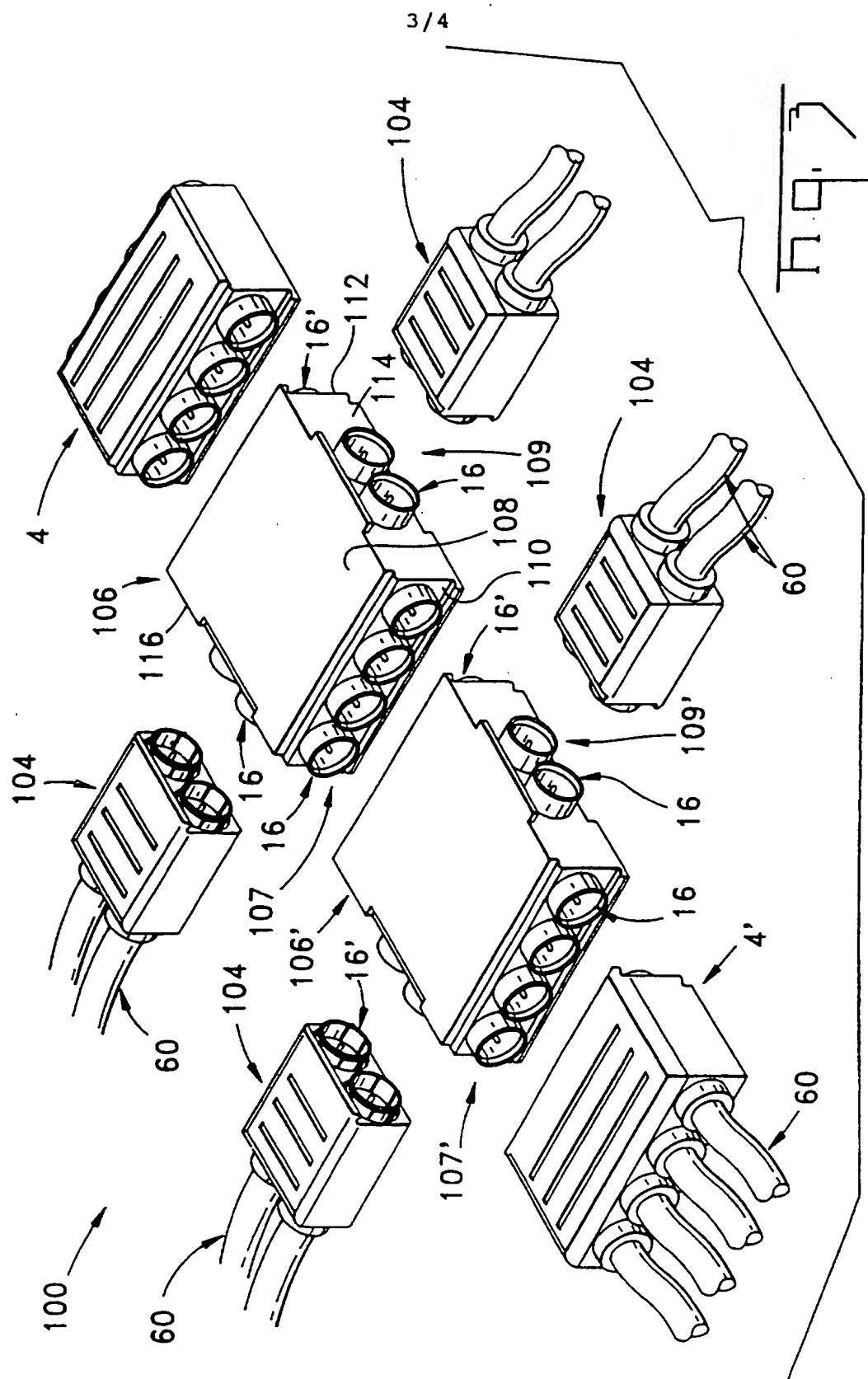
10. The assembly of Claim 9 wherein a plug (74) is provided in the cable receiving end of the cavity (10) for retaining the connector in the terminated position (T).

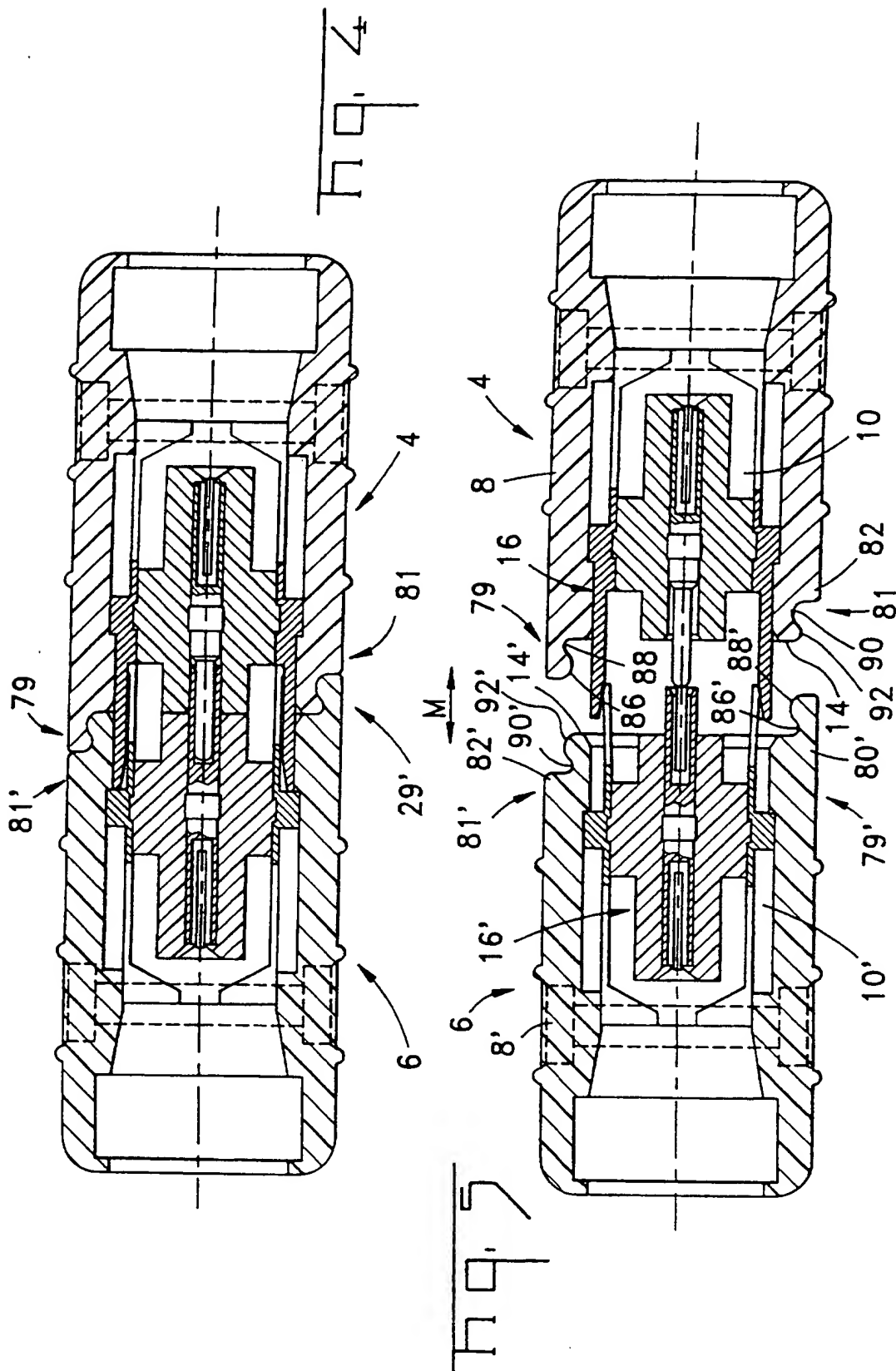
11. The assembly of any preceding claim wherein there are a plurality of the coaxial connectors (16) mounted in cavities (10) of the assembly housing (8).

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# INTERNATIONAL SEARCH REPORT

International Application No

PCT/IB 97/00189

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 H01R9/05

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 H01R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 1 109 914 A (HUTCHINGS E.L.) 18 April 1968	1-7,9
Y	see page 2, line 22 - line 88; figure 4 ---	8,11
X	DE 19 21 195 A (SIEMENS AG) 12 November 1970 see page 2, last paragraph - page 3, paragraph 1; figure ---	1-7,9
X	GB 2 249 433 A (WINTER, L.P.) 6 May 1992 see the whole document ---	1-7,9
Y	US 5 066 248 A (GAVER, JR. ET AL.) 19 November 1991	8,11
A	see column 2, line 54 - column 3, line 44; figures 7A,8 ---	1-7
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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search  23 May 1997	Date of mailing of the international search report  04.06.97
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax (+ 31-70) 340-3016	Authorized officer  Kohler, J

# INTERNATIONAL SEARCH REPORT

Inter nal Application No  
PCT/IB 97/00189

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 86 00473 A (AMP INCORPORATED) 16 January 1986 see figures 1,3	11
A	<p>---</p> <p>US 3 683 320 A (WOODS ET AL.) 8 August 1972 see column 3, line 51 - column 4, line 27; figure 2</p> <p>-----</p>	1-10

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information on patent family members

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